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Soy Lubricants Technical Background

UNITED SOYBEAN BOARD

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Driving Issues

Increasing market penetration of soybean oil lubricants will be driven by environmental, economic, conservation and performance issues. Petroleum-based oils, also known as mineral oils, will continue to be the most economical choice for many producers and provide certain original equipment manufacturer (OEM)-desired performance characteristics in many uses. However, soy and other vegetable oils show the ability to compete in significant segments of this market.

The need for readily biodegradable lubricants that are low in toxicity for environmentally sensitive areas has been recognized in Europe and by the U.S. government and is a research priority of the United Soybean Board (USB). Regulations have been adopted in some European areas, and both synthetic and rapeseed oil lubricants have been developed to substitute for mineral oils. Growing regulatory pressure to reduce or eliminate certain emissions of petroleum lubricants, along with Executive Order 13101, which instructs federal agencies to use environmentally preferable biobased products, should combine to encourage increased use of renewable oils.

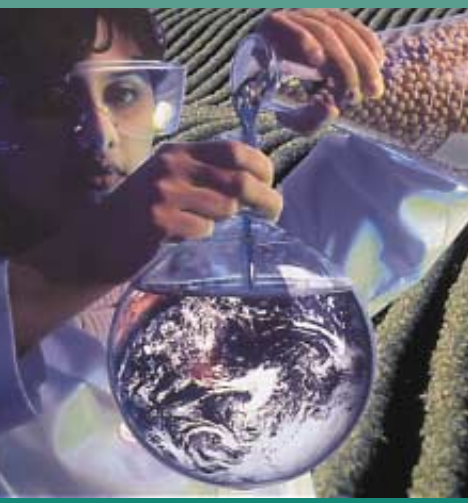
Competing Products

Soybean oil will compete for a share of any emerging renewable lubricants market with other vegetable oils, particularly rapeseed or canola, and with synthetic-based oils. Vegetable oils have performance limitations, particularly in thermal, oxidative and hydrolytic stability. These problems can be overcome by additives or by modification of the vegetable oil.

When compared with petroleum oils as lubricant base stocks, vegetable oils show the potential to provide performance advantages over finished lubricants:

- higher viscosity index (less viscosity change with changes in temperature)
- lower evaporation loss
- indications of higher lubricity (the ability to reduce friction and wear)

Vegetable oils, including soybean oil, are lower in cost than synthetic oils and will likely be the product of choice for this market segment when they can meet performance requirements. Development of a process to provide an economical and stable base stock is the key to the commercialization of soy-based lubricants.



A natural, renewable feedstock for industry.

Soy Compared with Rapeseed and Canola

Lubricants made from rapeseed oil have already been tried in Europe with some success. The chemical composition of rapeseed oil and its offspring, canola oil, are different from soybean oil, which allows them to be modified more easily for stability. Much of this development work on rapeseed/canola has been done.

Typical Chemical Composition of Oils (Fatty Acid Profile):

	16:0	18:0	18:1	18:2	18:3	22:1
Soybean oil	12	3	23	56	6	0
Mid-oleic soy*	9	3	53	32	3	0
Low-sat soy*	4	4	34	54	4	0
Rapeseed oil	4	1	19	22	8	45
Canola oil	3	1	64	22	8	1

*Approximate averages for new USDA varieties under development

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The important acids for stability are those labeled xx:2 and xx:3, which indicate the number of active sites for attack on each chain. The more sites, the less stable the chain is. The important acids for freezing point are those labeled xx:0. These fully saturated acids freeze the most easily and limit the low-temperature capabilities of the oil. As can be seen, soybean oil has the most challenging profile from this standpoint. The physical properties are an extension of the profiles.

Soybean oil has a significant advantage in cost and availability in the United States over rapeseed or canola oil. These advantages make it possible that soybean oil could capture a larger share of an emerging U.S. market for renewable lubricants, if the performance can be improved to mineral oil standards.

The applications where lubricants are lost directly to the environment – as from railroad rails and switches, wire cables on cranes, and the bars of chain saws and other power equipment – are the most likely to initiate the use of soy-based lubricants. In these limited-life applications, the stability of the lubricant is not a factor, giving soybean oil an advantage as the base oil.

Improving Soybean Oil

The key to acceptance of vegetable oils as high-volume lubricants such as crankcase oils or hydraulic fluid is the development of a process to provide an economic and stable base stock from soy. Four possible avenues for an improved soy base oil are being investigated:

- **Biotechnology to produce a more stable oil from the seed.** DuPont has developed a genetically modified soybean that produces high levels of oleic acid (18:1). This may achieve the first hurdle in the development of a base oil in which monounsaturated levels are superior to rapeseed/canola.

- **Nontransgenic modification to produce more stable oil.** USB has sponsored work by the Agricultural Research Service of the U.S. Department of Agriculture and multiple university cooperators to develop new varieties with superior oil traits using genes from wild and commercial soy varieties. Among the new varieties being developed are those with higher levels of oleic acid (18:1) and lower levels of saturated fats.

- **Processing changes.** Modification of the oil through chemical or mechanical processing to improve oxidative stability is under investigation by Archer Daniels Midland Company and others.

- **Chemical additives.** Additives that improve the stability offer the most rapid and cost-effective route to commercialization. USB-sponsored researchers have already made strides in this area.

A combination of several of these areas offers the greatest opportunity for achieving the use of significant levels of soybean oil in finished lubricant formulations. Coordinating the efforts of diverse groups is the challenge to commercialization.

Soybean Compared with Synthetic Oils

Synthetic oils, used in lubricants as the base oil, offer improved stability and performance over refined petroleum oils and current vegetable-oil-based lubricants, but at a price. Most of the environmentally friendly synthetic oils are chemical esters that offer superior thermal and oxidative stability. Prices for these niche products are higher than those for vegetable oils and significantly higher than those for petroleum-based lubricants. An improved soybean oil should be able to compete effectively against the synthetics.

If the European model is followed, some regulatory efforts around readily biodegradable lubricants may be made in the United States in the next five to 10 years. Regulations are more likely to be passed at the state level than at the federal level, as well as in environmentally sensitive applications or locations.

With an annual U.S. crop approaching 3 billion bushels, the potential supply of soybean oil could surpass 31 billion pounds (4 billion gallons) if the entire crop were crushed domestically. This availability, coupled with the price advantages over most other vegetable oils and synthetics, makes it logical that soybean oil will find a place in the market as a substitute for mineral oils.

The United Soybean Board is composed of 62 U.S. soybean farmers appointed by the Secretary of Agriculture to invest soybean checkoff funds. The soybean checkoff is a farmer-supported marketing and research fund collected on each bushel of U.S. soybeans sold. USB invests these funds on behalf of the 600,000 U.S. soybean farmers in activities specifically designed to increase the global utilization of U.S. soybeans and to reduce production costs. Checkoff-funded investment areas include human and animal health and nutrition, research and development of new uses, and research to improve soybean composition and production efficiencies. USB